Apparent Adverse Effect of *Marisa cornuarietis* upon *Lymnaea columella* and *Biomphalaria glabrata* in an Ornamental Pond in Puerto Rico*

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Fascioliasis hepatica, an important disease of sheep, goats, and cattle, occurs as human infection in rural Cuba, Russia (Hoffman, 1930; Kouri, 1948), Mexico, Chile, Uruguay, Venezuela, and Peru. In some parts of Peru, liver fluke disease has become a disturbing rural health problem in recent years, and it has been epidemic historically in Cuba (Kouri, 1948). The international total of human cases has been estimated at 100,000 (Pearson, 1960). This disease is widely distributed among ruminant animals in the British Isles, parts of continental United States, some of the Caribbean islands, Australia, and in countries around the Indian Ocean (Gretillat, 1961; Hoffman, 1930; Kendall, 1953; Krull, 1938; Lynch, 1965; Pearson, 1960; Von Volkenberg, 1929, 1934). *Fasciola hepatica* is replaced by the larger, less common fluke, *F. gigantica*, in parts of Africa, the Orient, and Hawaii.

Lymnaea snail vectors are widely distributed, and many species occupy ecological niches which differ but little (Alicata, 1953; Baker, 1911; Boray, 1963; Brenes, *et al.*, 1968; Cawston, 1937; Chock, *et al.*, 1961; Demian and Lutfy, 1964; Fisher and Orth, 1964; Gamet, *et al.*, 1964; Hoffman, 1930; Kendall, 1953; Krull, 1938; Lynch, 1965; Olsen, 1944; Pearson, 1960; Taylor, 1964; Van Der Schalie, 1948; Van Someren, 1946). Examples are *Stagnicola bulimoides* in Texas (Olsen, 1944), *Lymnaea truncatula* and *L. peregra* in the British Isles (Reinhard, 1957), and *L. columella* and *L. cubensis* in Puerto Rico (Hoffman, 1930; Van der Schalie, 1948; Von Volkenberg, 1929, 1934). Some species are intermediate hosts for both *F. hepatica* and *F. gigantica* (Gohar and El-Gindy, 1960). Being mostly

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amphibious, *Lymnaea* are difficult to study in the field, as first noted by A. P. Thomas in 1882 in the basic study of *L. truncatula* (Reinhard, 1957). Few species of *Lymnaea* are found in the West Indies, and *L. cubensis* and *L. columella* are the indicted vectors (Baker, 1911; Hoffman, 1930; Hubendick, 1951; Neff, 1964; Taylor, 1964; Van der Schalie, 1948). *Physa cubensis*, widely distributed in the West Indies, is also a liver fluke host (Perez-Viqueras and Moreno-Bonilla, 1938, 1940; Van der Schalie, 1948).

Since the 14th century, control of liver fluke has been achieved only temporarily and in small areas. There is common agreement on the need for control of the snail vectors (Alicata, 1953; Berg, 1959, 1964; Pearson, 1960; Radke, *et al.*, 1961; Reinhard, 1957; U. S. Department of Agriculture, 1961), but there is little agreement on auxiliary methods—removing cattle from infested pastures, fencing ponds, swamps, and streams, and filling and draining land to discourage snails (Boray, 1965). Several drugs are effective vermifuges, but all have toxic side effects, require careful management, and are relatively expensive (Boray, 1965; Neff, 1964; Taylor, 1964). The large amount of water requiring chemical molluscicidal treatment tends to make it impractical as an antifascioliasis measure (Anantaramin, 1955; Baker, 1911; Berg, 1964; Ferguson and Butler, 1966; Ferguson, *et al.*, 1958; Gordon, *et al.*, 1959; Moens, 1965; Neff, 1964; Pearson, 1960; Taylor, 1964). Permanent drainage of snail habitats has been the only definite solution to the problem; yet, some species are quite resistant to drying (Cawston, 1929; Gohar and El-Gindy, 1960). Known predacious agents for biological control of vector snails include snails (Chock, *et al.*, 1961; Boray, 1965); ducks, plovers, and wading birds (Taylor, 1964); fishes—carp, goldfish, gourami, and silurid catfish (Mvogo and Bard, 1964; Zakaria, 1963); and several insects—"glowworm" larvae, *Luciola* (Taylor, 1964), firefly larvae, *Lamprophorus tenebrosus* (Reinhard, 1957), and Sciomyzid marsh fly larvae (Berg, 1959, 1964; Chock, *et al.*, 1961; Fisher and Orth, 1964; Neff, 1964); plus a parasitic flagellate, *Dimoeriopsis* (Hollande and Chabelard, 1953).

History of Test Pond

During 1960–61, known colonies of *Lymnaea columella* and *Biomphalaria glabrata* were adversely affected by the artificial introduction of six adult *Marisa cornuarietis* and its progeny. *L. columella* disappeared completely 8-1/2 months after introduction of *Marisa*, and *B. glabrata* were drastically reduced in numbers. During this time, *Marisa* also consumed the decorative water lilies within our pond. The pond was treated with a molluscicide, Niclosamide (Bayluscide*), in October 1961 and was then drained, cleaned, and replanted with water lilies. During the following 6 months, in the absence of the predator snail, both *L. columella* and *B. glabrata* became re-established—*L. columella* moderately and *B. glabrata* abundantly (mod-

*Trade name is for identification only and does not constitute endorsement by the Public Health Service or by the U. S. Department of Health, Education, and Welfare.

erate populations = 12 to 17 per square meter; abundant = more than 17 per square meter). Bilharzia snails were probably introduced by egg masses attached to the undersurface of new lily plants; the liver fluke vector probably moved in from surrounding land vegetation.

Our purpose was to determine whether *M. cornuarietis*, a predator snail (Cawston, 1937; Demian and Lutfy, 1964, 1965a,b; Ferguson, 1970; Ferguson, *et al.*, 1958; Michelson and Augustine, 1957; Oliver-González, *et al.*, 1956; Radke, *et al.*, 1961), could control colonies of both Puerto Rican *L. columella* and *B. glabrata* in the same pond habitat.

Materials and Methods

Our study was conducted in a smooth-walled concrete ornamental lily pond set in a grass lawn at the University of Puerto Rico's Agricultural Experiment Station at Rio Piedras. The circular pond had an area of 82 square meters, a diameter of 10.2 meters, an average depth of 0.53 meters, and contained approximately 43 cubic meters of water below overflow level. Rainfall normally maintained the pond at full level.

Our 3-3/4-year study consisted of a series of weekly observations of all pond snails plus some final miscellaneous surveys. Counts were made arbitrarily of all snails in a peripheral test strip 61 cm wide, comprising an area of 20 square meters. During the week prior to study inception, 100 mature *Marisa* were planted from nearby pond stocks at a seeding rate of 1.2 snails per square meter of surface area. All snails were visually judged to be small, medium, or large. (See footnote to Table 1.)

Molluscs were not disturbed in any manner during the counting, which was done as the examiner moved slowly around the test strip on hands and knees. Counts were made around 9 or 10 AM, mostly on a Friday. Each observation required one man from 1 to 2 hours.

Results

Most of the *Lymnaea* remained within 60 cm of the pond's edge, either in or out of the water. When out of the water, some rested upon the leaves of lilies near the edge, sometimes in a drop of water. The reintroduced *Marisa* and *Biomphalaria* ranged freely within the pond on the shallow marginal slope and were attached throughout to vegetation. *Lymnaea* were free to retreat to the surrounding lawn, although limited searches did not reveal any. The greatest *Marisa* population was visible on the cooler wetter days; the predator apparently retreated to cooler depths on the warmer days. The general history of the pond suggested that more *Lymnaea* were visible in early morning compared to afternoon or early evening. In rainy periods many specimens were found venturing out upon the damp surfaces of lily pads or the moist concrete wall.

TABLE 1. *Size Class Array Observed for* Lymnaea, Biomphalaria, *and* Marisa *in a Puerto Rican Pond.*

Dates of Observation	*Number Observed by Size and Species*											
	Lymnaea				*Biomphalaria*				*Marisa*			
	Small	*Medium*	*Large*	*Total*	*Small*	*Medium*	*Large*	*Total*	*Small*	*Medium*	*Large*	*Total*
28-VIII-62 to 28-XII-62	106	247	132	485	2,265	11,210	3,756	17,231	63	142	529	734
4-I-63 to 11-IV-63	2	13	14	29	409	6,353	819	7,581	1,076	317	873	2,266
19-IV-63 to 26-7-63	140	206	91	437	21	1,268	484	1,773	903	970	3,129	5,002
3-VIII-63 to 11-X-63	8	40	45	93	0	5	2	7	330	677	1,669	2.676
	Average Number Per Week Observed by Size and Species											
28-VIII-62 to 28-XII-62	6.6	15.4	8.3	30.3	141.6	700.6	234.8	1076.9	3.9	8.9	33.1	45.9
4-I-63 to 11-IV-63	.13	.87	.93	1.9	27.3	423.5	54.6	505.4	71.7	21.1	58.2	151.1
19-IV-63 to 26-7-63	9.3	13.7	6.1	29.1	1.4	84.5	32.3	118.2	60.2	64.7	208.6	333.5
8-III-63 to 11-X-63	.8	4.0	4.5	9.3	0	.5	.2	.7	33.0	67.7	166.9	267.6

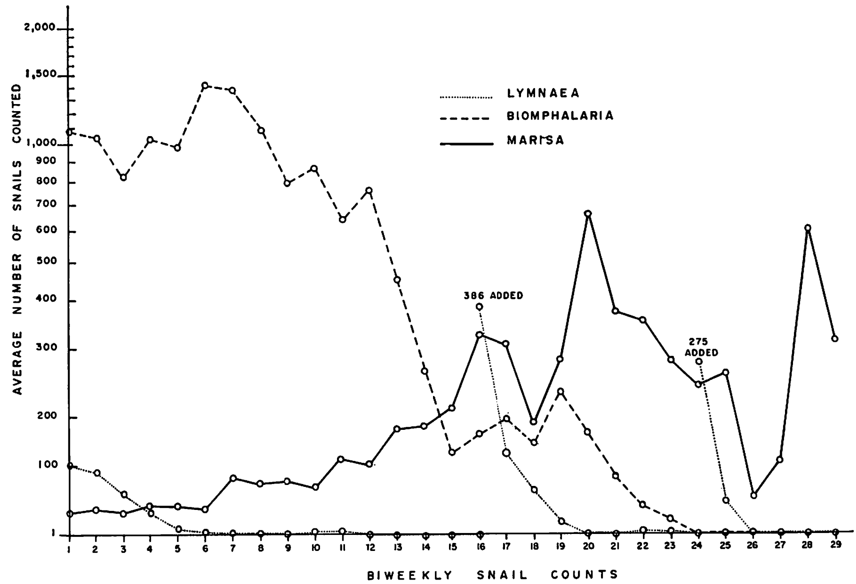

FIG. 1. *Comparison of average biweekly population densities observed for* Lymnaea, Biomphalaria, *and* Marisa *in a Puerto Rican pond,* 28 *August* 1962 *to* 11 *October* 1963.

In the test strip, 101 *Lymnaea* (5.0/m^2), 1,075 *Biomphalaria* (53.7/m^2), and 25 *Marisa* (1.2/m^2) were detected in the first count made in August 1962. The number of *Lymnaea* declined rather steadily, and none could be seen on 7 March 1963, about 6 months after trial inception (Table 1; Fig. 1). At this survey, *Biomphalaria* numbered 306 (15.4/m^2), and *Marisa*, 260 (13.0/m^2). The drop in number of *Biomphalaria* was fairly gradual as was the increase in *Marisa*. The *Lymnaea* count continued at zero for 6 weeks, and by plan on 15 April 1963, 386 mixed size *Lymnaea* were transferred from a nearby pond to the test pond. *Lymnaea* and *Biomphalaria* gradually declined to zero by 26 July 1963, about 3 months after the transplant. The *Marisa* population rose to about 300 (15.0/m^2) during this period, but only 85 (4.2/m^2) were counted on July 26. By plan on 31 July 1963, 275 *Lymnaea* from the same source as before were added. Again, the *Fasciola* vector rather abruptly declined to disappearance within 2 months. One to 3 *Biomphalaria* were found in 4 of the last 10 inspections prior to termination of the study. The snail predator population finally stabilized at about 400 (20.0/m^2). *Biomphalaria* disappeared at approximately the same time as the second introduction of *Lymnaea*, about 12 months after start of the study. The *Biomphalaria* population totaled 1,166 (58.2/m^2) at its height, began declining when the control snail population reached 88 (4.4/m^2), and disappeared when there was a peak population of 489, a snail density of about 24.5 *Marisa* per square meter. The bilharzia snail did not return by the end of the first weekly set of observations, March 1966. This observation agrees with an earlier quantitative assay of replacement of *Biomphalaria* in the field by *Marisa* (Radke, *et al.*, 1961).

During the *Marisa* population peak (September 1963), only scraps of lily plants remained of a thick covering of the entire pond. This is partial testimony to the rather extensive phytophagous ability of this snail in the control of certain surface and submersed aquatic weeds.

Following this study phase, the numbers of *Marisa* gradually dropped, presumably because of lack of food. Concurrently, Puerto Rico experienced a record drought from October 1963 through June 1965. Lack of normal, frequent rains and a serious fouling of the pond water from falling leaves and fruits of an overhanging *Ficus mysorensia* apparently destroyed the *Marisa* colony; terminal counts of 8, 6, and 2 were noted in May 1964. At the same time, another *Lymnaea* colony appeared spontaneously, the first count being 16 small specimens. Meanwhile, during the 6 months following the demise of *Marisa*, normal rainfall ensued and the pond became covered again with lilies recrudescing from buried roots. Despite the apparently well-balanced habitat, the *Lymnaea* population remained at a low level through August 1964, at which time it seemingly disappeared due to unknown causes. During the following 3 months, an effort was made to assist nature in re-establishing the colony by making a series of *Lymnaea* transplants at particular sites at the pond edge. Of the first transplant of 110 stock snails during the next week, only 17 could be seen, all confined within a 1.5 meter strip. Then, 106 specimens were seeded at another site, and 3 days later, only 16 of these were visible, all again in a sharply defined short strip. The following week, only 2 *Lymnaea* were seen in the pond.

Persisting in this vein in November 1964, 130 snails were placed at one position, of which 85 were counted 1 week later. The total count for the pond by then was 154. In January 1965, the population was reinforced by a last transplant of 374 snails. Subsequently, 20 surveys were made through March 1966, the end of our study. The *Lymnaea* population average was 140, and the counts ranged from 71 though 312, confirming continued population growth by the upward trend in total numbers. Specimens observed were predominantly small and medium sizes. Thus, *Lymnaea* finally again became strongly and uniformly colonized from the transplanted subcolonies. Suitability of the pond for this *Fasciola* vector species was again evident.

Discussion

The results indicated that *Marisa* dominated and then destroyed a flourishing colony of the bilharzia snail, *Biomphalaria*. Also, the predator snail presumably eradicated a colony of *Lymnaea* and subsequent transplants, as well as prevented population reinforcement from external sources. Puerto Rican *Marisa* is a demonstrated destroyer of important schistosomiasis snail vectors, species of *Biomphalaria* and *Bulinus* (Butler, *et al.*, 1969; Chernin, *et al.*, 1956; Demian and Lutfy, 1965a,b; Ferguson and Butler, 1966; Ferguson, *et al.*, 1958; Michelson and Augustine, 1957; Oliver-González, *et al.*, 1956). *Lymnaea* lays its eggs on vegetation in water in the same manner as *Biomphalaria.* Therefore, they are easy prey to the constantly browsing action of *Marisa* on the vegetation.

Although it was first thought that *Marisa* controlled these snails by consumption of the eggs and the young (Chernin, *et al.*, 1956), the mechanics of ingestion of bilharzial snails have been clearly delineated since then (Demian and Lutfy, 1965a, b). A similar account has been given of the method by which *Marisa* consumes the soft parts of *L. cailliaudi*, the host of *F. gigantica* in Egypt (Demian and Lufty, 1964). *L. cailliaudi* is held securely by the larger and stronger *Marisa* which gradually ingests the soft parts by progressively inserting its head and mouth into the shell. Egg masses are also eaten.

While one may assume that *Marisa* effectively reduces populations of *Biomphalaria* in the same aquatic habitat (Radke, *et al.*, 1961), one can only surmise this for that segment of the mobile population of amphibious *Lymnaea* within a waterbody, or that which enters it from outside. Following laboratory knowledge, *Marisa* probably controlled both *Biomphalaria* and *Lymnaea* by predation and, to some extent, through food competition in our study. There is also the possibility that *Biomphalaria* and *Lymnaea* disappeared from the pond due to environmental changes. Both the bilharzia and predator snails have much the same habitat preferences and can live in any truly aquatic habitat of the liver fluke snail in Puerto Rico. However, it is significant that *Lynmaea* re-established after *Marisa* was no longer present, assuring that later the pond was still a suitable habitat. Data suggest that control of *L. columella* by *M. cornuarietis* in the field is a possibility.

Summary

Populations of the Puerto Rican bilharzia snail, *Biomphalaria glabrata*, and the liver fluke snail, *Lymnaea columella*, were assayed quantitatively on a weekly schedule for 3-3/4 years as these disease vectors were opposed by the ampullarid predator snail, *Marisa cornuarietis*, in a single test pond. Excluding the possible detrimental effects of environmental changes in the pond, the predator snail apparently destroyed both the original and artificially introduced populations of *L. columella* as well as a flourishing colony of *B. glabrata.* Simultaneous control of both snails in the same aquatic habitat by the use of the predator snail is a possibility worthy of definitive field investigation.

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